

# Burden of COPD in a government health care system: a retrospective observational study using data from the US Veterans Affairs population

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**Background:** Health care utilization and costs among US veterans with chronic obstructive pulmonary disease (COPD) were compared with those in veterans without COPD.

**Methods:** A cohort of veterans with COPD was matched for age, sex, race, and index fiscal year to a cohort of veterans without COPD (controls) using data from the Veterans Integrated Service Network (VISN) 16 from 10/1/1997 to 9/30/2004. Annual total and respiratory-related health care service utilization, costs of care, comorbidities, and respiratory medication use at the time of diagnosis were assessed.

**Results:** A total of 59,906 patients with COPD were identified for a 7-year period prevalence of 8.2%, or 82 per 1000 population. Patients with COPD compared with controls had significantly higher all-cause and respiratory-related inpatient and outpatient health care utilization for every parameter examined including mean numbers of physician encounters, other outpatient encounters, emergency room visits, acute inpatient discharges, total bed days of care, and percentage of patients with any emergency room visits or any acute inpatient discharge. Patients with COPD had statistically significantly higher mean outpatient, inpatient, pharmacy, and total costs than the control group. The mean Charlson comorbidity index in patients with COPD was 1 point higher than in controls (2.85 versus 1.84,  $P < 0.001$ ). 60% of COPD patients were prescribed medications recommended in treatment guidelines at diagnosis.

**Conclusion:** Veterans with COPD compared with those without COPD suffer a tremendous disease burden manifested by higher rates of all-cause and respiratory-related health care utilization and costs and a high prevalence of comorbidities. Furthermore, COPD patients do not receive appropriate treatment for their disease on diagnosis.

**Keywords:** chronic obstructive pulmonary disease (COPD), veterans, health care utilization, costs, respiratory medicine, VA, economic burden, burden of illness

Chronic obstructive pulmonary disease (COPD) may be a particularly significant health concern among military veterans. COPD is common in veterans and was a primary cause of mortality, second only to cancer and vascular disease, in a cohort of retired military Chinese veterans followed over an 18-year period.<sup>1</sup> The high prevalence of COPD among veterans might be attributed to the strong association between combat experience and health risk behaviors including smoking,<sup>2</sup> which is the major cause of COPD. The Department of Veterans Affairs (VA) – one of the largest managed care organizations in the United States – is integrally involved in the care of veterans with COPD. Each year, the VA provides care for approximately 500,000 patients with a diagnosis of COPD,<sup>3</sup> and COPD is among the most common discharge diagnoses from VA hospitals.<sup>4</sup>

The VA health care system differs from other sectors of health care in the USA and resembles some of the international health care systems. Firstly, there are established

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enrollment eligibility criteria for use of the system. Secondly, the system does not provide incentives to the practitioners for under- or over utilization of health care resources. Thirdly, various specialists within the system review the literature and provide evidence-based guidelines for delivery of health care. Fourthly, due to its size, the VA health care system allows for negotiation of prices for various health care items at a significantly discounted level that can result in more cost effective delivery of health care systems. Finally, VA facilities uniquely represent a wide range of practice settings including academic and nonacademic hospitals and community-based health care facilities and thus diagnostic and treatment decisions are made by a variety of health care providers including pulmonologists, primary care providers, and allied health practitioners. The study of the burden of COPD in this system may provide information that can validly be applied to wide range of health delivery systems internationally.

The importance of the VA system to COPD care notwithstanding, little is known about health care utilization and health care costs in VA patients with COPD. The research that has been conducted suggests that VA patients with COPD frequently have other serious comorbid diseases, are significant users of health care resources, and are not being managed according to treatment guidelines.<sup>3-7</sup> The study described herein, which involved a large sample of VA patients in the southwestern United States, was conducted to examine health care utilization and costs to the VA for patients with COPD compared with veterans without COPD. To the authors' knowledge this study is the first large-scale assessment specifically aimed at assessing health care use and costs associated with COPD in the VA patient population.

## Method

The protocol for this segmented, historical, retrospective, matched-cohort study was approved by the Baylor College of Medicine Institutional Review Board and the Michael E. DeBakey VA Medical Center Research and Development Review Committee. This study included data collected between 1 October 1997 and 30 September 2004.

## Data source

Data were obtained from the VA Veterans Integrated Service Network (VISN) 16 Database Warehouse, a repository of administrative and clinical data from 10 Departments of VA medical centers in the south central United States. The VISN 16 Database Warehouse contains more than 759 million electronic medical records on more than 1.8 million patients. During the

current study, 729,347 patients were treated for all conditions in the inpatient and outpatient facilities of VISN 16.

The VISN 16 Database Warehouse includes hospital discharge abstracts, data on outpatient clinic visits, pharmacy prescription fill records, and costs of care. The inpatient, outpatient, pharmacy, and cost data are computerized for each patient at local VA medical centers and are aggregated at the VISN level into the Database Warehouse.

## Sample

Patients were eligible for the COPD group if they had a primary or secondary diagnosis of COPD based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes of 491.xx (chronic bronchitis), 492.xx (emphysema), 494.xx (bronchiectasis), 495.xx (allergic alveolitis), or 496.xx (chronic airway obstruction). The ICD-9-CM codes of 494.xx and 495.xx were allowed only if there were other COPD codes in other diagnosis fields. It is notable that very few COPD patients had only 494.xx or only 495.xx as stand-alone diagnoses. These two conditions, which generally are not used to define COPD, are relatively rare in patients with COPD and do not respond well to COPD medications including bronchodilators and inhaled steroids. Patients with bronchiectasis usually present with frequent infections and airflow obstruction and are treated similarly to patients with COPD. Patients with allergic alveolitis usually present with symptoms similar to those of COPD. More importantly, COPD patients with asthma diagnoses were excluded. The index date was defined as the first date of COPD diagnosis. Patients with ICD-9-CM codes for other respiratory conditions including asthma, interstitial fibrosis, sarcoidosis, pulmonary hypertension, and pulmonary embolism, along with patients diagnosed with cancer other than skin nonmelanoma cancer were excluded.

For each COPD case, two patients without COPD were randomly selected to form the control group, which was matched to patients with COPD with respect to age, race/ethnicity, sex, year in which the index diagnosis was made, and whether the index diagnosis was made in the inpatient or outpatient setting. Patients with any chronic respiratory condition were excluded from the control group.

## Measures and data analyses

Measures included annual total and disease-specific related health care service utilization, costs of care, total illness burden, and use of respiratory medications at the time of COPD diagnosis.

Outpatient utilization included the numbers of physician encounters (nonlaboratory visits), nonphysician outpatient encounters, and emergency room visits. Inpatient utilization included acute inpatient discharges and total bed days of care for inpatient stays. These measures were stratified according to whether or not they were related to respiratory causes. Cost of care was examined for each category of outpatient and inpatient health care utilization. Pharmacy costs were summed for all pharmacy services. Respiratory-related health care utilization and costs were examined for the time period from 366 to 730 days following the patient's index date, defined as the first date at which COPD was listed as a first or second diagnosis in either the inpatient or outpatient setting for patients with COPD and as the date of the encounter at which the patient was matched with a corresponding COPD patient for controls. Costs were examined beginning 366 days after index. Patients with an index date before 10/1/1998 were not included in these analyses because cost data were only available from 10/1/1999. Health care resource use was defined as respiratory-related if it involved the same ICD-9-CM codes used to define the population of COPD. This methodology is commonly accepted in retrospective observational studies whereby costs associated with a medical claim in the administrative database are attributed to the primary/secondary diagnosis on that claim.

Total illness burden for each patient was determined by constructing the Deyo-adapted version of the Charlson Comorbidity Index.<sup>8</sup> For each patient, all inpatient discharges and all outpatient visit records were searched for one year prior to index date to determine the presence of 17 comorbid conditions, identified using corresponding ICD-9-CM diagnosis codes, comprising the Charlson Comorbidity Index components.<sup>8</sup> The comorbidity index was constructed for each patient using

the sum of the weighted values. Indicator variables for the following 13 comorbid conditions of interest were similarly created: depression; angina; cardiac dysrhythmias; pulmonary embolism; pneumonia; acute upper respiratory infection; otitis media; disorders of lipid metabolism; hypertension; osteoporosis; gastroesophageal reflux disease; septicemia; alcohol/drug abuse, dependence, or poisoning.

Respiratory medication use in the following therapeutic categories was examined for the patients with COPD: inhaled corticosteroids; long- or short-acting beta-agonists; long- or short-acting anticholinergics; and inhaled corticosteroids/long-acting beta-agonists combination agonists. All prescriptions filled within 90 days prior to or after the index date were searched for use of these classes of medications.

Bivariate comparisons between patients with COPD and control patients were made for all demographic measures, measures of utilization and costs, the Charlson Comorbidity Index and individual Charlson comorbidities, and the 13 additional comorbidities using *t*-tests and Chi-square tests as appropriate.

## Results

### Baseline demographics

A total of 59,906 patients with COPD were identified for a 7-year period prevalence of 8.2% and were matched to 117,546 patients without COPD (Table 1). Mean age, gender, sex, and race/ethnicity distributions were comparable between patients with COPD and controls.

### Health care utilization and costs

Patients with COPD compared with controls had statistically significantly greater inpatient and outpatient health care

**Table 1** Baseline demographics

	COPD patients (N = 59,906)	Control patients (N = 117,546)	P value
Mean age, years (SD)	65.63 (11.24)	65.52 (11.77)	0.074
Age group, n (%)			
<40 years	833 (1.39)	2025 (1.72)	<0.0001
40 to 54 years	9968 (16.64)	19,538 (16.62)	
55 to 64 years	14,821 (24.74)	29,432 (25.04)	
65 to 74 years	19,778 (33.02)	36,538 (31.08)	
75+ years	14,506 (24.21)	30,013 (25.53)	
Male, n (%)	58,579 (97.78)	114,904 (97.75)	0.6616
Race, n (%)			
White	42,346 (70.69)	82,486 (70.17)	0.2801
Black	8366 (13.97)	16,687 (14.20)	
Hispanic	362 (0.60)	717 (0.61)	
Other	270 (0.45)	535 (0.46)	
Missing/Unknown	8562 (14.29)	17,121 (14.57)	

**Abbreviations:** COPD, chronic obstructive pulmonary disease; SD, standard deviation.

utilization for every parameter examined including mean numbers of physician encounters (nonlaboratory visits), other outpatient encounters, emergency room visits, acute inpatient discharges, total bed days of care, and percentages of patients with any emergency room visit or any acute inpatient discharge compared with controls (Table 2). These differences applied both to respiratory-related health care use and health care use related to all other causes.

Furthermore, patients with COPD had significantly higher mean outpatient, inpatient, pharmacy, and total costs for both respiratory health care utilization and health care utilization related to all other causes compared with controls (Table 2). Mean respiratory-related total health care costs (the sum of the outpatient, inpatient, and pharmacy costs) were approximately 10 times higher in patients with COPD than controls (\$676.68 versus \$68.50 per patient for the second year of utilization,  $P < 0.0001$ ).

## Comorbidities

Patients with COPD had a significantly higher comorbid illness burden than controls (Table 3). The mean Charlson Comorbidity Index in patients with COPD was one point higher (indicating at least one comorbidity more, on average) than in controls (2.85 versus 1.84;  $P < 0.0001$ ).

Myocardial infarction, congestive heart failure, peripheral vascular disease, rheumatologic disease, peptic ulcer disease, and malignancy/lymphoma/leukemia were significantly more frequent in patients with COPD than in controls (Table 3).

Table 4 shows other baseline comorbid conditions for COPD group versus the control group.

## Medications

Approximately three fifths (60.6%) of patients with COPD were receiving some type of respiratory medication (Table 5). The most common respiratory treatment was short-acting

**Table 2** Second-year utilization and cost outcomes<sup>1</sup>

		Respiratory-related			All other			Overall		
		COPD	Control	P value	COPD	Control	P value	COPD	Control	P value
<b>Health care resource use</b>										
# of physician encounters (non-lab visits) <sup>2</sup>	Mean	0.75	0.075	<0.0001	4.58	3.37	<0.0001	5.33	3.44	<0.0001
# of other outpatient encounters <sup>2</sup>	Mean	0.17	0.01	<0.0001	6.20	3.89	<0.0001	6.37	3.90	<0.0001
# of emergency room visits <sup>2</sup>	Mean	0.13	0.023	<0.0001	0.48	0.250	<0.0001	0.61	0.274	<0.0001
Any emergency room visit <sup>3</sup>	n	3,666	1,666	<0.0001	9,323	11,600	<0.0001	10,804	12,277	<0.0001
	%	8.56	1.94	na	21.80	13.56	na	25.25	14.35	na
# of acute inpatient discharges <sup>4</sup>	Mean	0.072	0.0059	<0.0001	0.134	0.072	<0.0001	0.206	0.078	<0.0001
Total bed days of care <sup>5</sup>	Mean	4.97	1.17	<0.0001	8.90	12.07	<0.0001	13.87	13.24	<0.0001
Any acute inpatient discharge <sup>5</sup>	n	2,356	452	<0.0001	3,651	4,199	<0.0001	5,227	4,455	<0.0001
	%	5.50	0.53	na	8.53	4.91	na	12.21	5.20	na
Length of stay <sup>5</sup>	Mean	3.84	1.07	<0.0001	5.70	8.31	<0.0001	9.54	9.38	<0.0001
<b>Costs</b>										
Outpatient \$	Mean	191.72	21.30	<0.0001	1,616.90	1,071.31	<0.0001	1,808.62	1,092.60	<0.0001
Inpatient \$	Mean	484.97	47.21	<0.0001	2,144.09	1,126.89	<0.0001	2,629.06	1,174.10	<0.0001
Pharmacy \$	Mean	na	na	na	na	na	na	1,256.10	747.10	<0.0001
Total \$	Mean	676.68	68.50	<0.0001	3,761.00	2,198.20	<0.0001	5,693.78	3,013.80	<0.0001

**Notes:** <sup>1</sup>This table shows utilization and costs for the time period from 366 to 730 days following the patient's index date. For patients with COPD, the index date is the first date at which COPD was listed as a first or second diagnosis in either the inpatient or outpatient setting. For controls, the index date is the date of the encounter at which the patient was matched with a corresponding COPD patient. Patients with an index date before 10/1/1998 were not included in this table because cost data were only available starting on 10/1/1999. <sup>2</sup>Number and percentage of patients with one or more visits to a VA outpatient clinic. <sup>3</sup>Mean number of days on which a patient visited one or more VA outpatient clinics. <sup>4</sup>Mean number of discharges among all patients in the cohort, including those with no hospital stays. <sup>5</sup>Total bed days of care, mean length of stay, and number and percentage of patients are among patients who had one or more hospital stays at a VA acute care facility.

**Abbreviations:** COPD, chronic obstructive pulmonary disease; NA, not available; VA, veterans Affairs.

**Table 3** Charlson Comorbidity Index and Charlson Comorbidity Index components

	COPD patients (N = 59,906)	Control patients (N = 117,546)	P value
<b>Charlson Comorbidity Index, mean (SD)</b>	2.85 (1.46)	1.84 (1.52)	<0.0001
<b>Charlson comorbidity index components, n (%)</b>			
Myocardial infarction	1828 (3.05)	3103 (2.64)	<0.0001
Congestive heart failure	6270 (10.47)	5937 (5.05)	<0.0001
Peripheral vascular disease	3238 (5.41)	4238 (3.61)	<0.0001
Cerebrovascular disease	3848 (6.42)	7701 (6.55)	0.3010
Dementia	681 (1.14)	1965 (1.67)	<0.0001
Chronic pulmonary disease	59,906 (100)	0 (0)	na
Rheumatologic disease	992 (1.66)	1473 (1.25)	<0.0001
Peptic ulcer disease	2083 (3.48)	2586 (2.20)	<0.0001
Mild liver disease	518 (0.86)	981 (0.83)	0.5121
Diabetes – mild to moderate	8182 (13.66)	21,613 (18.39)	<0.0001
Diabetes with chronic complications	2257 (3.77)	5573 (4.74)	<0.0001
Paraplegia or hemiplegia	418 (0.70)	1074 (0.91)	<0.0001
Renal disease	1425 (2.38)	2672 (2.27)	0.1614
Any malignancy/lymphoma/leukemia	6367 (10.63)	11,561 (9.84)	<0.0001
Moderate or severe liver disease	143 (0.24)	386 (0.33)	0.0011
Metastatic solid tumor	0 (0)	0 (0)	na
Acquired immune deficiency syndrome (AIDS)	510 (0.85)	1473 (1.25)	<0.0001

**Abbreviations:** COPD, chronic obstructive pulmonary disease; SD, standard deviation.

beta-agonists, which were prescribed to 54.5% of patients with COPD at baseline. Less than 1% of patients with COPD were receiving an inhaled corticosteroid/long-acting beta-agonist combination at the time of diagnosis.

## Discussion

In this study we have demonstrated the huge impact of COPD on the US VA population. Almost 1 in 10 patients in the southeastern US seen in the VA health care system had COPD. This prevalence is higher than the 42 per 1000 estimated by the National Center for Vital Statistics<sup>9</sup> but generally comparable to estimates from the National Heart Lung and

Blood Institute.<sup>10</sup> The 8.2% prevalence rate in the current study is consistent with previous observations suggesting that veterans have a higher burden of illness than nonveterans.<sup>11</sup> Patients with COPD compared with age-, race-, sex-, and index year-matched patients without COPD in this study had higher rates of inpatient and outpatient utilization and higher costs of care for respiratory conditions and all other conditions. In patients with COPD compared with controls, mean total respiratory-related total health care costs (the sum of the outpatient, inpatient, and pharmacy costs) were approximately 10 times higher, and total costs for all other conditions were approximately 1.7 times higher. The results suggest that the

**Table 4** Baseline other comorbidities, n (%)

	COPD patients (N = 59,906)	Control patients (N = 117,546)	P value
Depression	6279 (10.48)	10,014 (8.52)	<0.0001
Angina	3006 (5.02)	3605 (3.07)	<0.0001
Cardiac dysrhythmias	5414 (9.04)	8506 (7.24)	<0.0001
Pulmonary embolism	173 (0.29)	165 (0.14)	<0.0001
Pneumonia	3226 (5.39)	1870 (1.59)	<0.0001
Acute upper respiratory infections	6489 (10.83)	5707 (4.86)	<0.0001
Otitis media	656 (1.10)	1053 (0.90)	<0.0001
Disorders of lipid metabolism	613 (1.02)	1087 (0.92)	0.0439
Hypertension	28,233 (47.13)	54,126 (46.05)	<0.0001
Osteoporosis	723 (1.21)	677 (0.58)	<0.0001
Gastroesophageal reflux disease	587 (0.98)	686 (0.58)	<0.0001
Septicemia	291 (0.49)	689 (0.59)	0.0070
Alcohol/drug abuse, dependence, or poisoning	12,519 (20.90)	12,539 (10.67)	<0.0001

**Abbreviation:** COPD, chronic obstructive pulmonary disease.

**Table 5** Baseline respiratory pharmacotherapies among patients with COPD

	n	% of total 59,906	% of treated 36,285
Treated <sup>1</sup>	36,285	60.6	100.0
Inhaled corticosteroid+long-acting beta-agonist combination, any	449	0.7	1.2
Inhaled corticosteroid+long-acting beta-agonist combination 250/50	261	0.4	0.7
Inhaled corticosteroid	11,177	18.6	30.8
Short-acting beta-agonist	32,629	54.5	89.9
Long-acting beta-agonist	2,176	3.6	6.0
Short- or long-acting anticholinergic	13,493	22.5	37.2
Untreated <sup>2</sup>	23,621	39.4	na

**Notes:** <sup>1</sup>Defined as receiving medications in these drug class groups within 90 days before or after the index date. <sup>2</sup>Not treated with any of these groups.

**Abbreviation:** COPD, chronic obstructive pulmonary disease.

high prevalence of COPD and the excess health care resource use in the VA population place a substantial burden on the federal government to provide care for these patients.

It is difficult to compare the costs of care in this VA with those described in other studies due to differences in study designs, populations studied, and methodology used, as well as disparate health care systems in place. However, the VA system, when stacked against systems used in European countries, doesn't seem as farfetched a comparison upon closer comparison. There are established eligibility criteria for enrollment, no resource-based incentives are offered, decisions are formulated on the basis of evidence provision, and there is a strong negotiating power due to its size, as well as the fact that the government is involved. In fact, this system may be similar to national insurance health care systems seen in many European countries. This study therefore can add to the body of literature aimed at studying COPD as a disease and costs from the perspective of a government-based health care system. Studies of the costs of COPD in other countries corroborate results of the current study by demonstrating the substantial economic impact of COPD, particularly in patients with severe disease and/or frequent exacerbations.<sup>12-15</sup> Costs reported in this study are not expenditures by the patient, but are derived from the VA perspective, which allocates costs to services from a global budget for a given year. Costs in the VA system vary based on the number of services provided (more services and lower budget mean lower average costs). In 2000, the mean annual Medicare expenditures in the US were \$11,841 for patients with COPD compared with \$4901 for all covered patients.<sup>16</sup> In a study of 6,793 Texas Medicaid patients with COPD, the annual costs of care totaled \$11,580

per patient.<sup>17</sup> In the current study, total costs during the second year of utilization of services for patients with COPD were \$4,437 per patient. This value is comparable to the mean costs of care in a study of VA patients with chronic conditions.<sup>18</sup> The costs of care in the current study are therefore consistent with those described in previous VA populations but substantially lower than those in patient populations from other health care systems in the United States.

The high frequency of comorbid conditions adds to the disease and cost burden in the VA population. This finding corroborates other research conducted in non-US patients not selected with respect to veteran status.<sup>19</sup> In the current study, patients with COPD compared with controls were significantly more likely to have comorbidities including chronic debilitating or life-threatening diseases. The high frequency of comorbidities in veterans with COPD has been described in other studies.<sup>5,6</sup> In a study of 70,679 patients with COPD hospitalized at a VA hospital in 1998, the prevalence of cardiovascular comorbidities substantially exceeded that in an age- and gender-matched cohort without COPD at 33.6% versus 27.1% for coronary artery disease, 24.4% versus 13.5% for congestive heart failure, and 14.3% versus 10.4% for atrial fibrillation.<sup>5</sup> Comorbidities can also increase the risk of poor outcomes following an exacerbation of COPD. A study of 51,353 patients discharged after an exacerbation of COPD in the VA system identified pulmonary hypertension and weight loss as risk factors for death.<sup>6</sup>

In a recent study of 6,793 Texas Medicaid patients with COPD,<sup>17</sup> the mean Charlson Comorbidity Index was approximately 1.9, a value similar to that seen in the control cohort but approximately one point lower than that seen in the COPD cohort in the current study. Furthermore, 7% of COPD patients in that study were hospitalized for any cause versus 14.0% in the current study, although 83% of the Medicaid patients had emergency department visits versus 30.4% in the current study. Patients in the current study were more likely to be seen in the inpatient setting, an observation that suggests greater severity of illness among patients with COPD in this study than in the Texas Medicaid study.

Perhaps the most striking finding in the current study is the seeming undertreatment of the COPD population. Approximately 40% of patients were not receiving any of the medications recommended in global treatment guidelines<sup>20</sup> at baseline. The most common respiratory medication prescribed for these patients with COPD was short-acting beta-agonists, which according to treatment

guidelines are to be used as rescue medications and not as maintenance treatment. Maintenance treatment with guidelines-recommended long-acting bronchodilators was prescribed in the minority of patients in the current study. These findings are consistent with results of studies from Canada, Japan, and Europe, in which patients were not selected based on veteran status.<sup>21-24</sup>

Strengths of the current study include the large sample size and the examination of patients in a federally funded and operated integrated managed care system. As VA physicians are salaried and as Congress determines the total VA health care budget, few negative incentives operate either to limit care for VA patients or to exaggerate the illness burden in order to garner more resources. The results of the current study therefore are likely to reflect actual illness burden and health care use for these patients. The matched case-control design, which contributes to good internal validity, lends strength to the rigor of this study. The matched design allowed the utilization and cost measures to be adjusted for demographic, temporal, and contextual variables to reduce confounding.

Codes for bronchiectasis and allergic alveolitis were included in the ICD-9-CM-based definition of COPD in this study. Patients with bronchiectasis usually present with frequent infections and airflow obstruction and are treated similarly to patients with COPD. Patients with allergic alveolitis usually present with symptoms similar to those of COPD. Because these cases were so few in number (0.15%), they are unlikely to have affected the results. Notably, multiple diagnosis fields are included on medical claims in VA administrative data. In the very few cases of bronchiectasis and allergic alveolitis that were observed, COPD was also present on these medical claims. The clinical reasons explained above did not permit a clear rationale for excluding these cases.

This study has certain limitations inherent to retrospective observational studies involving claims data. Accuracy and completeness of diagnosis codes cannot be verified. However, the VA has relatively complete utilization records and is less susceptible to problems of coding bias that may occur in other managed care systems. The reliance of this study on VA pharmacy prescription fill records for estimates of medication use is a limitation that could have led to underestimation of medication use. The records do not contain information on out-of-plan (non-VA) prescriptions, such as Medicaid or Medicare or private insurance, for which the veteran may be eligible, nor do they capture over-the-counter pharmacy use. While the extent of out-of-plan or out-of-network

pharmacy use cannot be determined, it is thought to have been relatively infrequent. Also, the pharmacy prescription records for this study were obtained only from VISN 16 data warehouse records and did not include VA prescription fills outside of VISN 16. The data were obtained from a primarily male VA population and cannot be generalized to women or nonveterans. Although comorbidities play a role in overall cost burden to the VA system, comorbid conditions can also increase COPD complexity pathologically and in economic terms. For example, having cardiovascular disease may make COPD exacerbations more common; therefore, having that comorbidity will increase the costs involved with treating COPD as well. Therefore, it may not be entirely accurate to say that all those costs are part of a global chronic burden for patients. Admittedly, lack of functional data prevents conclusive exploration of this issue. Another limitation may be lack of adjustment for presence of comorbidities. In the absence of objective lung function data (absent in administrative claims databases such as the VA), one cannot say with complete certainty whether rates of maintenance treatment were indeed lower. This is a limitation found in administrative claims databases like the VA system. Finally, the study was conducted in the United States, and the generalizability of the results to other countries is not known. However, as discussed earlier, the VA system design is similar to countries in Europe that have national health care models. Therefore, there is possibility that the results from this study are applicable to those countries. Within the United States, however, the VA system is very different from closed network health maintenance organizations (HMOs), commercial health plans, and federally funded Medicare and Medicaid programs.

In conclusion, veterans with COPD compared with those without COPD suffer a tremendous disease burden with high rates of all-cause and respiratory-related health care utilization and higher health care costs. Furthermore, a significant number of these patients remain untreated, a finding corroborating data from other studies.<sup>21,22,25</sup> The results underscore the undertreatment of COPD in the current health care system. Future researchers should examine treatment strategies and interventions that may help reduce the burden of COPD in the veterans population.

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## Conflicts of interests

Anand A Dalal is employed by GlaxoSmithKline. Amir Sharafkhaneh is a speaker for GlaxoSmithKline, Boehringer Ingelheim, Pfizer, and Dey and has participated in advisory boards for GlaxoSmithKline, Pfizer, and Dey Pharmaceuticals. Nancy Petersen and Hong Yu report no conflicts of interest. Nicola Hanania has received research grant support and served as a consultant or speaker for GlaxoSmithKline, Dey, Sepracor, Novartis, and Boehringer Ingelheim. Michael Johnson has received research grant support from GlaxoSmithKline in connection with this study.

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